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A proposal for the renewal of sectoral approaches building on the Cement Sustainability Initiative

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The prospect of an international agreement within the United Nations Framework Convention on Climate Change (UNFCCC) resulting in a common response to carbon pricing, such as a global cap-and-trade scheme, can for now only be seen as a long-term goal. In the meantime, it is realistic to operate within a world of unilateral climate policies, which are eventually loosely coordinated among a limited number of countries. Two key considerations need be addressed in the design of these policies: equity for emerging countries according to the principle of 'common but differentiated responsibilities', and competitiveness within carbon-intensive, internationally traded sectors. The need to address both concerns has generated a renewed interest in the use of sectoral approaches. This article proposes a new sectoral framework approach using the case of the cement industry, within which equity and efficiency requirements are addressed. The proposed approach combines basic components put forward by industry, such as the use of absolute caps for industrialized countries and intensity targets for emerging countries, the introduction of a border carbon adjustment (BCA) on imports from those countries that do not adopt the sectoral approach, and the use of financial transfers collected through CO_2 revenues in industrialized countries. Notwithstanding the political and legal challenges associated with implementing a BCA, how such an approach would involve 'sticks' as well as 'carrots' incentivizing participation within the proposed scheme is described, and some key implementation issues are discussed.

Keywords: carbon leakage; cement industry emissions; climate policy frameworks; leakage

La perspective d'un accord international au sein de la convention cadre des Nations Unies sur le changement climatique (CCNUCC) résultant en une réponse commune pour la fixation du prix du carbone – telle qu'un système mondial de plafonnement et échange – peut pour l'instant seulement être vue en tant que cible à long terme. En attendant, il n'est pas réaliste de fonctionner au sein d'un monde de politiques climatiques unilatérales, qui sont finalement faiblement coordonnées par un nombre limité de pays. Deux considérations clés doivent être prises en compte dans la conception de ces politiques : équité pour les pays émergents en fonction du principe de *responsabilités communes mais différenciées*, et compétitivité au sein de secteurs à forte intensité carbone du commerce international. La nécessite d'aborder les deux questions a entraîné un regain d'intérêt dans l'utilisation des approches sectorielles. Cet article propose une nouvelle approche de cadre sectoriel appliqué au cas de l'industrie du ciment, au sein duquel les conditions d'équité et d'efficacité sont abordées. L'approche proposée allie des éléments de base avancés par l'industrie, tels que l'emploi des plafonds absolus pour les pays industrialisés et des cibles d'intensité pour les pays en développement, l'introduction d'ajustements à la frontière sur le carbone (AFC) pour les importations de ces pays n'ayant pas adopté l'approche sectorielle, et l'emploi de transferts de fonds recueillis par les recettes en CO_2 dans les pays industrialisés. Nonobstant les défis politiques et juridiques associés à la mise en œuvre des AFC, la manière dont une telle approche incorporerait « le bâton et la carotte » pour encourager la participation au système proposé est décrite et des questions clés liées à la mise en œuvre sont discutées.

Mots clés : fuite de carbone; émissions de l'industrie du ciment; cadres de politiques climatiques; fuite

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1. Climate change international agreements from a game-theory perspective

The history of international negotiations on climate change can be analysed from a political economy perspective. Godard (2011a) emphasizes the key role of 'common but differentiated responsibilities', 'competitiveness' as well as 'national sovereignty' in structuring the long series of rounds associated with the Kyoto Protocol.

At the conceptual level, Barrett (2010) suggests that international agreements in climate change should be analysed using the concepts of threats and promises from a game theoretic perspective, and not as a multilateral binding agreement to be signed by all parties (a 'comprehensive view' perspective that dominated the rounds before Copenhagen, at least from a EU standpoint). This article follows this line of thought and treats the climate change negotiations as a non-cooperative game between subsets of players. The stakes are the implementation of a well-defined sectoral approach,[1] using threats and promises such as border carbon adjustments (BCAs) and financial transfers. It is argued that the issues of 'common but differentiated responsibilities' and 'competitiveness', discussed by Godard (2011a), would be better accommodated from this game-theory perspective than from the 'comprehensive view' approach, which makes the achievement of a binding agreement on all parties improbable. It is further argued that this new perspective has merits compared to the pure voluntary approach underlying the recent post-Copenhagen discussions.

The article is aimed at the policy level, remains exploratory in many respects, and is based on a formal analysis of the proposed scheme in a simplified economic setting detailed in Meunier and Ponssard (2011).

In Section 2, the Cement Sustainability Initiative (CSI)[2] is taken as a starting point, adding some flexibility in its design.[3] The concepts of a BCA and financial transfers are also introduced. In Section 3, a well-defined sectoral approach, which can be implemented with one coalition of countries joining the agreement while other countries do not, is provided. In Section 4, some implementation issues are discussed. In Section 5, a review of the internal and external stability of the proposed scheme is offered and some limitations and areas for further research are also discussed.

2. The CSI as a starting point

The case of cement is an important example to use in a discussion of sectoral approaches. It is a highly carbon-intensive industry, ranking second only to lime in terms of value at stake from carbon costs (Hourcade et al., 2007). It is also a relatively homogeneous traded commodity, and has been identified to be potentially at risk from competitiveness and leakage impacts (e.g. Demailly and Quirion, 2008; Ponssard and Walker, 2008).[4]

At the world level, the industry is fairly concentrated. Consolidation is an ongoing trend, and given the patterns of demand and recent events leading to collapsing sales in many Organisation for Economic Co-operation and Development (OECD) countries, cement firms are seeking to diversify geographically and gain footholds in various important emerging markets. The world cement industry may thus be seen as a network of regional oligopolies (Ghemawat and Thomas, 2008). Major cement firms, such as Cemex, Holcim and Lafarge, typically operate a large number of plants.[5] The existence of such networks allows these firms to optimize their sourcing of production at any point in time depending on local supply and demand conditions. At this stage of market consolidation, a sectoral agreement between just a handful of countries/parties (including the EU, US, China and India) could affect around 80% of world production.[6]

To get a feeling for how sensitive this industry is to carbon costs, consider the following back-of-the-envelope calculation: given a typical EU price range of EU€80–100/t and an average CO_2 intensity of 0.7 t CO_2/t cement, then a CO_2 price of €30/t would result in a cost increase of $0.7 \times 30 = €21$/t, that is, approximately 25% of the current price range. Ponssard and Walker (2008) suggest that sector pass-through rates are fairly limited (particularly for coastal producers). Although not yet observed, the introduction of a unilateral climate policy such as the EU Emissions Trading Scheme (EU ETS) may have a considerable impact on international trade flows and on future investments (see Ellerman et al., 2010, for an assessment of EU ETS Phase I and Meunier and Ponssard (2009) for an argument regarding the potential impact on future investment).

In recent years, the cement industry has been active in promoting a form of sectoral approach to reducing CO_2 emissions. The corresponding work has been undertaken by the CSI, an industry initiative involving the major multinational cement producers, including some Chinese producers. It covers around 30% of world production (and 73% of the production of Annex I Parties). The CSI started operations in 2000 with a research phase, and in 2002 developed an agenda for action with measurable targets and individual company commitments. A number of reports were issued in 2009, including (WBCSD, 2009a), in which producers report on their energy and CO_2 performance, a Technology Roadmap for cement (WBCSD, 2009b), and the conclusions of the Sectoral Approach modelling project (WBCSD, 2009c).

The sectoral approach proposed by the CSI is particularly interesting. It is elaborate, but remains incomplete. Scenarios explore possible responses by the global cement industry over the period 2005–2030 assuming future demand in the various world regions, available technologies, and including present and future abatement opportunities (e.g. energy efficiency, fuel switching, increased blending, carbon capture), production and transport costs. Four key scenarios are compared:

1. *Sectoral approach*: Annex I countries commit to deep global targets for industrial CO_2 emissions, and non-Annex I countries commit to intensity targets (adjusted on a country-by-country basis).
2. *No commitments*: No CO_2 regulations are implemented.
3. *Global caps*: There is a uniform global CO_2 price.
4. *EU caps only*: CO_2 regulation is only implemented in the EU.

A key conclusion of the model is that, for a total cement demand of 5200 Mt of cement in 2030, sector CO_2 emissions would rise to 3500 Mt under the 'no commitments' reference scenario, 2000 Mt with 'global caps' and 2600 Mt with the 'sectoral approach'. This last scenario is considered a feasible target. However, the proposal appears incomplete in two ways: it does not address the issue of competitiveness and falls short of describing important implementation issues (including e.g. how to attract the various stakeholders into the deal and, in particular, why governments might buy into such a sectoral approach). These two issues are interdependent.

The role of competitiveness can be examined in the context of the 'EU caps only' scenario. The implementation of this scenario would generate a carbon leakage to reduction ratio of 56%; that is, for every tonne of CO_2 reduced in the EU, there would be a corresponding 0.56 t CO_2 increase in the rest of the world (associated with increased foreign cement production to meet EU demand). This figure is in line with other studies that seek to model the cement sector leakage potential (Meunier et al., 2011) and illustrates the limitations of unilateral policies introduced to address what is essentially a global problem.

The CSI suggests two possible approaches to deal with the issues of competitiveness and leakage: the introduction of border adjustments and free allocation to European cement firms. The European Commission has not yet chosen BCAs, although their future use has not been ruled out. Free allocation has

been adopted for a large share of European industry, under Phase III of the EU ETS, based on the use of benchmarking. This article revisits the relative merits of both options.

3. A sectoral approach package based on the CSI concept

The 'sectoral approach package' (SAP) will now be described according to Table 1. The combination of a cap and trade, sectoral approach for cement, BCA and financial transfers as implemented by each country (labelled in columns) appears in the last line of the table. Several steps are listed in the rows of Table 1 to make precise the content of the SAP relative to business-as-usual (BAU):

- Step 0 corresponds to BAU.
- Step 1 marks the starting point adopted for cement in the CSI and the cap-and-trade system, in reference to BAU (including the use of free allocation).
- Step 2 introduces BCA.
- Step 3 introduces financial transfers and wraps everything together to achieve the SAP.

It should be noted that the sectoral approach and the cap-and-trade system are redesigned throughout the process (the elimination of free allocations for cement, the introduction of intensity targets in cement based on t CO_2/t cement, and so on).

TABLE 1 Summary of the proposed SAP

	Countries included in the SAP		ONA1 countries (rest of world)	Key issues
	A1 countries	SNA1 countries		
Step 0 (BAU)	BAU			Climate change mitigation not addressed
Step 1 (CSI)	Technology roadmap			Equity partially addressed in SNA1 through use of intensity targets Competitiveness and leakage issues arise from differential CO_2 prices between A1, SNA1 and ONA1
	Cap and trade with absolute targets; free allocation to cement firms	Sector intensity target	BAU	
Step 2	Elimination of free allocation; BCA on ONA1 imports	Export taxes on cement and clinker from SNA1 to A1		Competitiveness and leakage issues are addressed
Step 3 (SAP)	Financial transfers from A1 to SNA1 (from allowance auction revenues)	Higher eligibility for financial transfers	Lower eligibility for financial transfers (which incentivizes move from BCA to full participation)	Feasibility of financial transfers is facilitated through increased CO_2 revenues in A1 countries

Source: Authors.
Notes: A1, industrialized countries; SNA1, Some Non A1; ONA1, Other Non A1.

In the columns of Table 1, the key issues and how they are addressed as one moves from BAU to the SAP are illustrated. We start with Step 1. The CSI Technology Roadmap may be used in those countries that adopt the SAP to set standards for either CO_2 intensity targets in SNA1 countries (Some Non-Industrialized Countries) or the allocation of free allowances in industrialized countries (A1) that have adopted cap-and-trade systems such as the EU ETS. To be effective, a free allocation approach needs to be output-based rather than based on grandfathering (Quirion, 2009). However, an output-based approach has one important drawback: it eliminates the carbon price signal to consumers and thereby the incentive to switch consumption to alternative and less carbon-intensive products. Technically, the EU ETS during the period 2013–2020 will be similar to an output-based approach.[7] However, the actual implementation of such a system appears complicated; it is awkward to monitor (because allocations are based on thresholds of past used capacities), it will not favour industry restructuring within the EU (because a number of small inefficient plants will need to be closed), and it may not even reduce the incentive for firms to relocate production outside the EU (because some gaming within the system may allow for maintaining free allocations while importing). Furthermore, the very act of introducing free allocations for some sectors has led to an inflation of so-called 'exposed' sectors: 164 of a total of 256 sectors have been declared exposed, amounting to 75% of total industrial emissions (excluding the emissions of the energy sector).[8]

Step 2 addresses competitiveness and leakage issues in two ways.[9] It introduces BCABCA on imports from ONA1 countries (Other Non-Industrialized Countries). For SNA1 countries it is proposed that they directly monitor an export tax based on the CO_2 emission content of their own exports to A1 countries, using the prevailing CO_2 price in the country of export destination. Exporters then have an option to provide alternative data if this is better than the default factors chosen.[10] As a consequence of these two measures, free allocation to cement producers in A1 could be eliminated, because as far as carbon pricing is concerned there would now be a level playing field for the cement sector worldwide. The price signal for incentivizing reduced cement consumption would be back in A1 countries. Step 2 is thus a clear improvement over Step 1.

Step 3 sets the stage for financial transfers from industrialized countries to emerging countries, as suggested at the UN Climate Change Conferences in Copenhagen and Cancun. Our idea builds on this proposal, in terms of both the origins of the funds and their destination. In terms of funding it is proposed that part of the transfers come from revenues collected through the auctioning of CO_2 emission rights in A1 countries. The elimination of free allocation in industrialized countries increases the amount of revenues from CO_2 auctioning. Regarding how such transfers could be used, it is proposed that an SNA1 country that joins the SAP sees its share of these transfers increase. In this way there would be a clear incentive for countries to join the agreement. Indirectly, because under the proposed approach the export taxes remain in the country of origin, such countries would also benefit from changing from a BCA regime to an export tax regime.

Step 3 goes further and it is proposed that these financial transfers are administered as offsets more in line with sectoral crediting than CDM projects. As an illustration, consider the electricity sector in SNA1 with funds coming from allowance auctioning in the EU. Some of the financial transfers would be earmarked for achieving sector emission intensity goals by covering the incremental cost of abatement; all eligible projects in the electricity sector would be considered at a sector level rather than on a project basis (as has been the case, e.g., with wind farms developed in China under the CDM; see He and Morse, 2010). Earmarking funds for a specific country and sector makes this possible and eliminates many of the criticisms made against the CDM (Schneider, 2007; Wara, 2007; Wara and Victor, 2008).

4. Implementation issues

In this section we discuss how the SAP proposal bypasses a number of traditional arguments against the use of sectoral approaches. After reviewing how targets and baselines can be defined for intensity based for SNA1 countries (i.e. tonne of CO_2 per tonne of cement produced), the relationships between the three types of countries – A1, SNA1 and ONA1 – with respect to export taxes, border adjustments and financial transfers are then clarified.

For emission reductions to be considered meaningful, national intensity targets must be far above BAU baseline if they are to be considered meaningful. There are different options here: if the form of the target were based on an agreed percentage reduction in intensity over a certain period (perhaps annually) then an assessment of potential BAU projection of sector carbon intensity would be required. Data in WBCSD (2009b) indicate that sector performance has improved in all world regions over recent years. This trend is expected to continue, for example, as blending rates and the use of alternative fuels increase and older kilns are closed. A sector-focused approach, such as involving country-specific targets for new and existing facilities might therefore be more appropriate. However, the need to ensure target stringency remains a key policy requirement. Both targets and baselines must also serve to reflect national factors fairly, including fuel use, materials availability and existing technology. Targets must be based on what is technically feasible and at an economic cost across participating countries. In this context, intensity targets would probably need to be developed by means of an output-based allocation approach, which would aim to equalize marginal abatement costs between countries.

An important policy issue concerns the actual process by which targets and baselines are developed and agreed between participating countries. Several studies have considered the development and negotiation of sector targets within a UNFCCC framework (e.g. CCAP, 2010). A key benefit of a sectoral approach is that, by focusing on only one sector and a handful of key producing countries, it could help speed up the effectiveness of abatement efforts and opportunities without relying on the strained process of UNFCCC negotiations. The role of host (SNA1) governments would, however, be very important, in both their involvement in reaching agreements and establishing the appropriate national supporting policies and measures to assist the cement sector in meeting the relevant targets. For example, this might be achieved by amending building and product codes, incentivizing energy efficiency through best practice schemes and energy subsidy removal, and improving national waste management and biomass availability. Thus, sectoral agreements reached within the cement and other industrial sectors could be implemented by SNA1 governments as part of their Nationally Appropriate Mitigation Actions (NAMAs).

Industry experts drawn from A1 and SNA1, or third-party, countries could form a panel to assess proposed baselines and targets forwarded by each of the participating countries and to assess best available technology (BAT) and national circumstances. As with any effective mitigation policy, such a system would require robust and common approaches to measurement, reporting and verification (MRV). In this regard, the CSI/GNR database provides a useful methodological basis. Although intensity targets require additional data sources (i.e. output), these would likely not be problematic for the sector; unlike many other sectors, cement and clinker are reasonably simple homogeneous products, and do not give rise to complex definitional and product scope considerations. However, in theory at least, there is an incentive for SNA1 countries to overstate production levels (in relation to emissions levels) and so, as with the emissions MRV requirements, a third-party verification agreement relating to plant production might be envisaged.

There are also some important issues to consider in the design and implementation of a BCA applied to ONA1 countries. The administrative requirements, costs and technical practicality of accurately

determining the level of emissions linked to a BCA may be the greatest barrier to its implementation (Reinaud, 2009). The development of robust, plant-level, MRV requirements is costly and resource-intensive, requiring a significant amount of political and administrative effort in low-cost producing countries located in developing Asia and Africa, for example. Because a commonly agreed and robust MRV approach allowing for plant-by-plant data collection does not exist globally, some form of simplification will inevitably be required, at least in the near term.

Although not as pronounced as in other sectors, the degree of carbon intensity variability within the cement industry means that calculating the carbon content of imported clinker and cement on the basis of simple BAT benchmarking may still give rise to domestic producers facing higher carbon costs than those levied on imports. Similarly, a more stringent use of simple benchmarking (e.g. a high level of t CO_2 per tonne of clinker/cement) would unfairly penalize against many foreign producers. Table 2 compares these two extremes (a plant-by-plant system and the use of import benchmarking) with an alternative approach. This alternative approach, based on a set of suitably stringent default factors but with the option available to producers to demonstrate their plant-level emissions intensity, would appear to represent a sensible and practical compromise. Importantly, such an approach may incentivize greater use of plant-by-plant MRV, thereby acting as a useful bridge to a full plant-by-plant assessment of carbon content (and a basis for ONA1 participation in the SAP).

Applying a range of default factors on the basis of some key criteria would appear to be a sensible approach to reducing the inaccuracy of a simple BAT-type approach. Under most US proposals for

TABLE 2 Summary of BCA design options

Option	Advantages	Disadvantages	Overall assessment
Plant-by-plant assessment	Carbon intensity of imported products determined with greatest level of accuracy, thereby maximizing BCA effectiveness and limiting legal disputes under the WTO	Imposes significant administrative burden, cost and time to develop robust MRV approaches Requirement for foreign action would require much policy effort	Practical and political challenges likely to limit feasibility in the short term. CSI-GNR programme may provide workable basis for such an approach over longer term
Benchmarking	Benchmarking on basis of BAT performance is simple and avoids extensive MRV requirements with associated political issues	Determining appropriate level poses significant challenges. A too stringent level would penalize some exporters, raising WTO legal issues; a level set too low could only partially equalize carbon costs, limiting effectiveness of BCA	Choice of level based on BAT or best performance would be relatively workable and potentially avoid legal issues. However, competitiveness and leakage concerns would only be partially addressed
Default factor with option for plant-level evidence	Combines simplicity of benchmarking approach with stringency (and therefore effectiveness) of plant-by-plant assessment. May incentivize greater use of MRV within sector globally	Many design issues relevant to other options remain, including e.g. choice of appropriate default factor and basis for MRV protocol acceptable to domestic regulator	Presents potentially workable compromise in the context of the cement sector and potential bridge to plant-by-plant assessment

Source: Authors.

border adjustments, for example, the carbon content of imported goods will be assessed using a national average for the country of origin. What would be the most appropriate basis for such an approach for the cement sector? Criteria based on CO_2 per tonne of clinker are likely to represent the most workable basis; developing cement criteria would be more complex due to product definition and process complications. However, applying pure clinker benchmarking to all products would have the disadvantage of not rewarding greater use of clinker substitution (a key abatement lever for the sector). A potential approach is therefore to use pure clinker benchmarks combined with average national clinker content factors, based on equivalent cement, meaning cement produced from own-produced clinker. Concerning the scope of emissions coverage within such an approach, the complexities involved in determining regional grid emissions intensity combined with the relatively low use of electricity in cement production suggest there is little benefit in seeking to include indirect CO_2 emissions. Certain elements may require modification through suitable formulations. For example, there is potential for carbon price spikes to arise in the A1 market, which, by dramatically increasing BCA, could lead to political difficulties.

The introduction of export taxes by SNA1 countries is unlikely to present any novel issues. Many cement-producing regions (including key producers such as Egypt and China) have developed procedures for applying various taxes and/or rebates on clinker and cement exports. Accounting for plant-level emissions (and the chain of custody from plant to port) does not pose a particular difficulty. The development of a suitably robust MRV system with third-party verification again represents a key requirement of such a scheme. Another important feature is that such an approach does not effectively require an enforcement or penalty system (other than a robust MRV system). Financial transfers from an A1 country can be linked to the performance of an SNA1 country, and those parties who break the agreement (e.g. through misreporting data) could face the imposition of a BCA. There are therefore 'sticks' as well as 'carrots' within the proposed SAP approach.

5. Incentives to participate in the SAP

A major factor for the proposed SAP to become attractive to different countries is whether there are the right incentives for participation. Countries that adopt the sectoral approach are referred to as 'the coalition'. Consider the standpoint of industrialized countries; domestic industrial producers, subject to international competition, are not worse off under the SAP. Export taxes in developing countries inside the coalition, or import charges in developing countries outside the coalition, make the competitive situation roughly equivalent to free allocations under the initial cap-and-trade scheme. The price signal may impact producers' sales, but price elasticity in the cement sector is low. The financial transfers come from the increased revenues collected from the cap-and-trade system, through the elimination of free allocations. This makes these transfers more acceptable to policy makers worried about tight public budgets. Moreover, the border adjustment measures relax the pressure from producers on national governments about competiveness and provide an argument to eliminate free allocations at the EU level.

Developing countries in the coalition benefit from increased transfers, receive more direct financial transfers and generate revenue through export taxes. Defecting from the SAP means a step back to a situation in which a developing country will have no competitiveness advantage, as its trade partner would apply a border tax.

Developing countries that do not join the coalition therefore have an individual incentive to join in. The adoption of intensity targets is in line with the individual pledges already made under the Copenhagen Accord. Moreover, the level of financial transfers will increase.

6. Summary and conclusions

A new framework for an international agreement to combat climate change, involving emissions trading schemes, and sectoral approaches such as BCAs and financial transfers, has been proposed. The framework was illustrated using the CSI as a starting point. It was assumed that industrial countries set a common cap-and-trade scheme and that industrial countries and some developing countries adopt a sectoral approach, with the elimination of free allowances for producers in the industrial countries and the introduction of intensity targets in developing countries. Both sets of countries implement a BCA with respect to the sector concerned. The adjustment for imports is replaced by an export tax if the developing country adopts the sectoral approach. In this situation, the financial transfers originating from industrial countries are increased, because the replacement of import tariffs by export taxes constitutes an indirect financial transfer to the exporting countries.

The potential merits of such a framework certainly need to be explored in more detail to be fully assessed. From a strict economic perspective, the limited efficiency loss relative to a first-best mechanism (with transfers), as demonstrated in Meunier and Ponssard (2011), needs to be recast into a full-blown computable general equilibrium model.

Further implementation issues need be considered, such as the way in which national or regional cap-and-trade schemes are linked (Tuerk et al., 2009; Dellink et al., 2010), MRV procedures in the sector involved in the sectoral approach (considered to be almost at hand in cement), the origins of financial transfers in industrial countries (which have here been limited to the carbon market), and the conditions for recipients in developing countries.

Finally, proper attention should be paid to the issue of governance. How would governments be involved? What would the political risks be if the border tax scheme were to degenerate into a trade war (limited in our view to the case of cement)? Is the transfer mechanism politically acceptable?

Despite these limitations, such proposals are worth exploring, given the limitations encountered with the 'comprehensive' climate treaty approach mentioned at the beginning, and the risk of inconsistency associated with the implementation of individual country pledges.

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Notes

1. A sectoral approach represents a combined industry and government initiative. Such an approach stipulates that, for the countries signed up to the agreement, there are joint binding rules to mitigate CO_2 emissions in some industries. As a matter of principle, these rules must be quite flexible. For example, they may include a cap-and-trade system, a set of intensity targets, or a set of technical norms; they may apply to one sector or to several sectors at once; they may also differ from one country to another. Baron et al. (2009) and CCAP (2010) provide an exhaustive analysis of the various forms that a sectoral approach may take.
2. The CSI proposal was for a new CDM methodology based on simple benchmarks for cement and clinker plants.
3. Cement is listed as a prime candidate for sectoral approaches in Dröge and Cooper (2009).
4. Its degree of openness to international competition is selective; cement is costly to transport on land but not on sea, which makes most coastal regions easily accessible to imports.
5. According to their 2009 websites, Cemex operates 79 plants (in 50 countries), Holcim 151 plants (in 70 countries) and Lafarge 166 plants (in 79 countries).

6. According to the latest US Geological Society data, the levels of hydraulic cement production in 2008 were as follows: China (1388 Mt); the EU (230 Mt); India (177 Mt); the US (88 Mt); Japan (63 Mt); South Korea (54 Mt); Russia (54 Mt); Brazil (52 Mt); Turkey (52 Mt); Mexico (48 Mt).
7. See EC (2010).
8. See for instance http://ec.europa.eu/environment/climat/emission/carbon_en.htm.
9. In general equilibrium models, leakage in a world of unequal carbon prices comes from a (small) direct competitiveness impact on internationally traded sectors and a (large) indirect impact coming from the price changes in energy goods (Kuik, 2001). Sectoral BCA has no impact on the second factor, yet it may be necessary to induce industry to go from Step 1 to Step 2.
10. For a recent review of the political issues associated with BCAs, such as compatibility with the World Trade Organisation, see Godard (2011b).

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